Lighting and Gearbox Control

for remote-control model lorries

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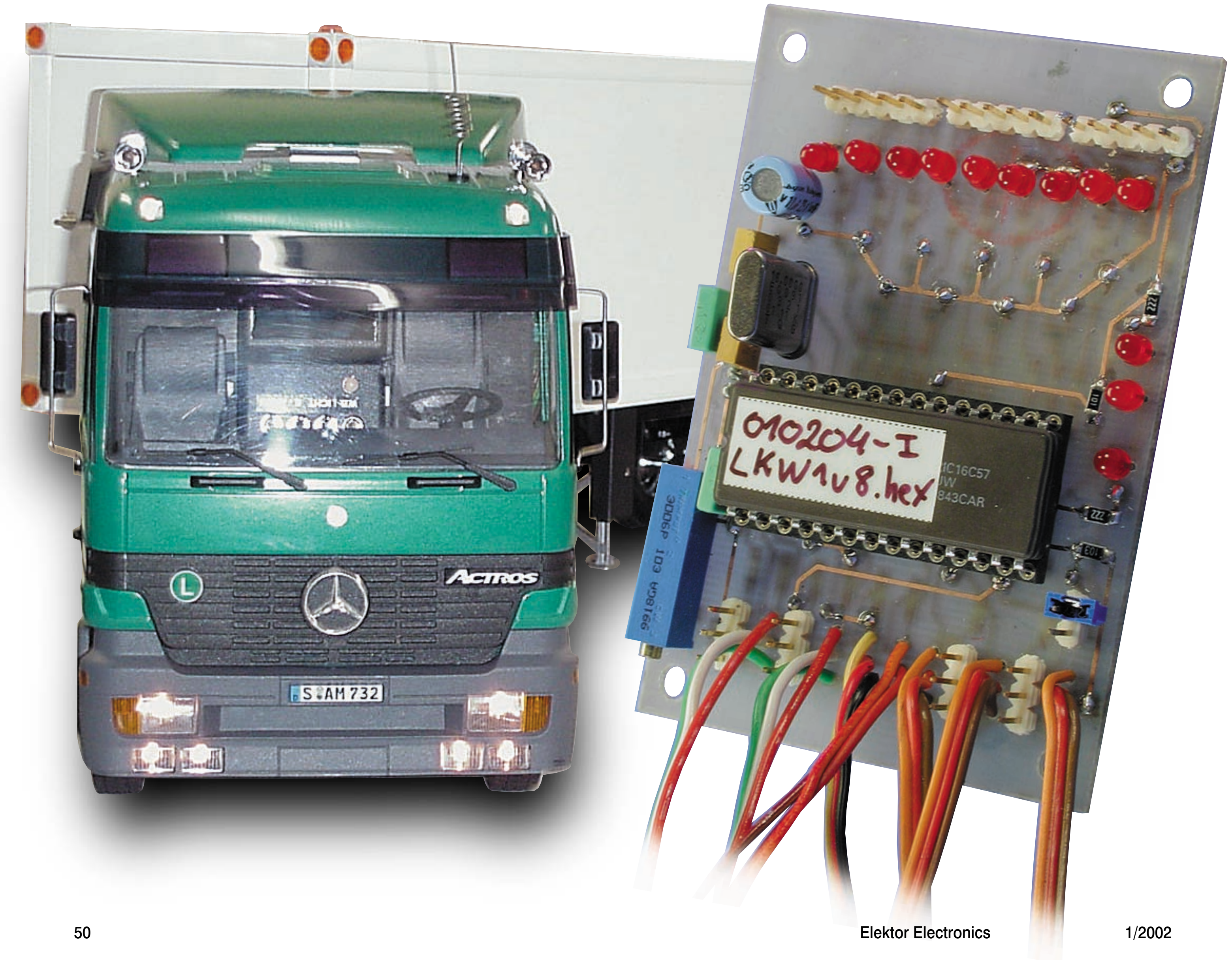
The circuit described here uses a PIC microcontroller to take over the complete control of the lighting and gearbox in a model lorry. It can also be used with a fork-lift truck, excavator or similar type of vehicle.



Technical data

Supply voltage:	5V (from receiver)
Current consumption:	less than 10 mA (excluding lamp currents)
External supply voltage:	5–12V
Blinking rate:	fixed, approx. 0.5 Hz
Gearbox servo travel:	adjustable using a trimpot
Trailer coupling servo direction of rotation:	selectable (left/right) using JP1
Maximum current per output:	0.3 A

Keyed output for control only (max. 10 mA)

Relays may be connected (only with flyback diodes!)

Note regarding the maximum lamp current:

If the lamps are powered from the internal supply voltage (see Figure 5) using the receiver–speed controller BEC, the maximum output current of the speed controller BEC must not be exceeded!

The problem with these kinds of remotely controlled vehicles is that they have a large number of functions, which normally means that an expensive remote-control unit must be used. The project presented here consists of a small printed circuit board, featuring a microcontroller from the popular Microchip PIC family, which looks after the extended functions. This involves a combination of automatic function control and the decoding of supplementary functions.

The automatic functions are:

- turn indicators are automatically activated when the vehicle is turned;
- the brake lights go on when the accelerator is released;

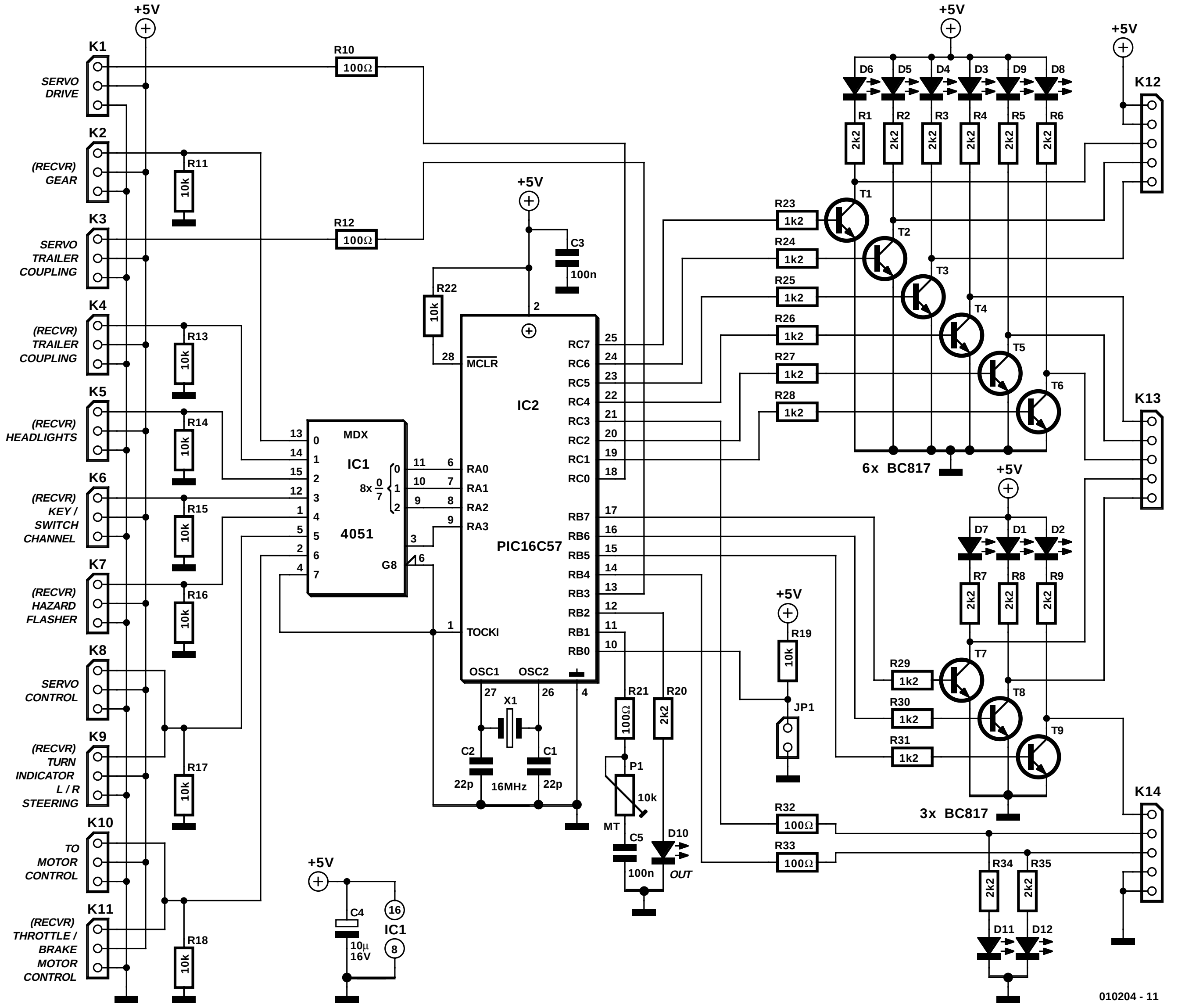


Figure 1. Schematic diagram of the lighting and gearbox controller. The microcontroller evaluates the pulse signals from the remote control receiver and generates the additional control signals for the lights and gearbox.

BEC

The acronym 'BEC' simply stands for 'battery eliminator circuit'. This is a circuit that eliminates the need for a separate battery to power the remote control by providing an adequately processed (stabilised and decoupled) supply voltage from the motor battery pack. In a model lorry, this BEC is built into the speed controller (the motor controller for the tractor). Such speed controllers always include a BEC with a 5-V output voltage. In the case of special regulators for lorries, this 5-V output can supply a heavier load than a normal regulator for cars. The amount of output current that can be supplied by the regulator depends on the model and ranges from 1 to 3 ampères.

– the back-up lights go on when the vehicle moves in reverse.

Supplementary switches on the remote control unit can be used to switch on the dipped beams, main beams, hazard flasher, flashing lights on the driver's cab, horn and additional output channels.

Lamp current

The current consumption of the circuit with no lamps connected is less than 10 mA. Each of the nine outputs connected to the transistors can switch a maximum of 300 mA, which altogether yields (9 × 0.3 A) = 2.7 A! This amount of current can only be provided by an external power source (wired as shown in Figure 6).
If the internal 5-V supply voltage is used (wired as shown in Figure 5), the 5-V output of the vehicle's speed controller must supply not only the current for the remote control receiver and the servos, but also the total lamp current. Consequently, if there are many lamps, a speed controller that can provide 1.5 A or more should be used. The following is a suggestion for the lamp selection (5 V / 40 mA lamps):

dipped beams:	6 × 40 mA	=	240 mA
main beams:	2 × 80 mA	=	160 mA
brake lights:	4 × 40 mA	=	160 mA
back-up lights:	2 × 40 mA	=	80 mA
blinkers:	6 × 40 mA	=	240 mA
hazard flashers:	2 × 40 mA	=	80 mA
switched channel:	1 × 80 mA	=	80 mA
Total lamp current:			1.04 A

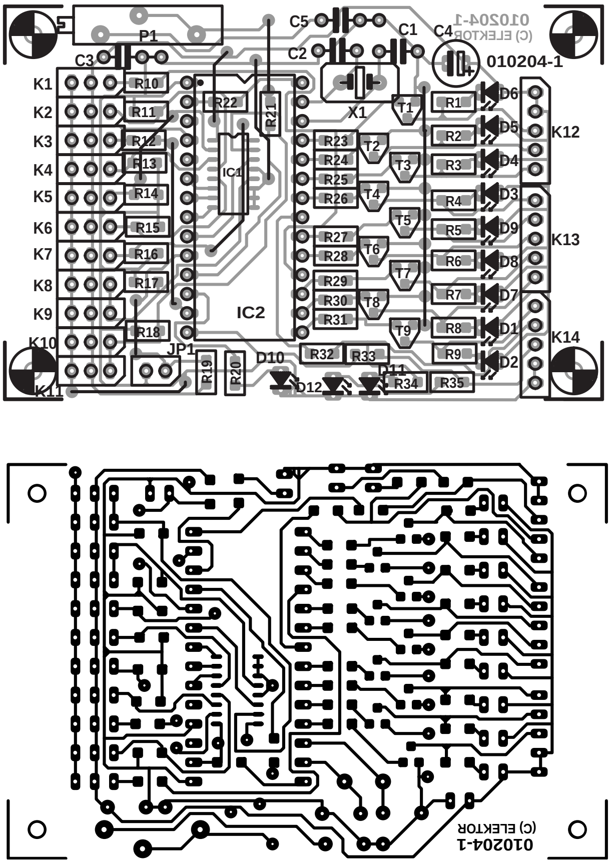


Figure 2. Printed circuit board track layout and component layouts for the copper and component sides of the single-sided circuit board.

Furthermore, the gearbox servo can be sequentially shifted up or down using a switch or the control stick (just like a real Porsche, but with only three gears…).

Finally, there is a trailer function,

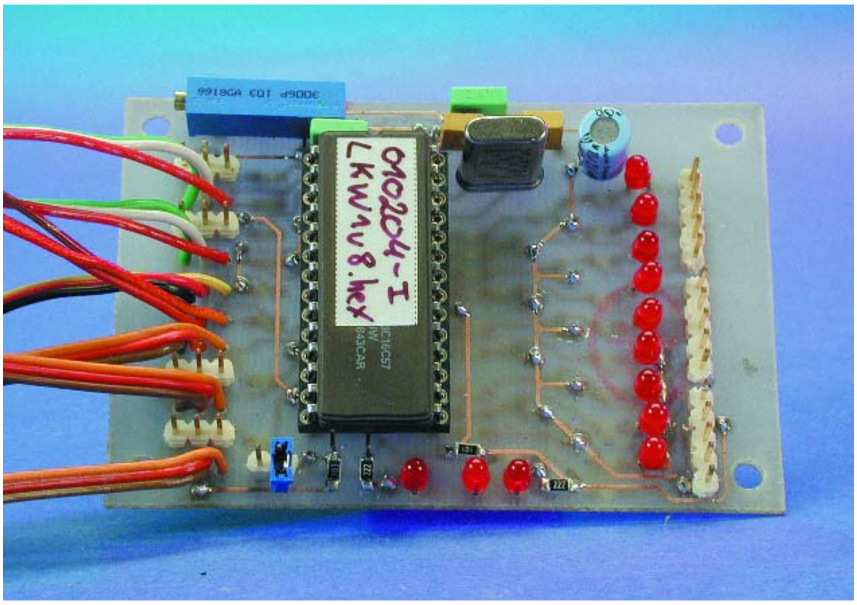


Figure 3. Top view of the prototype circuit board.

COMPONENTS LIST

Resistors:
R1-R9,R20,R34,R35 = 2kΩ2
R10,R12,R21,R32,R33 = 100Ω
R11,R13-R19,R22 = 10kΩ
R23-R31 = 1kΩ2
P1 = 10-turn preset, horizontal mounting

Capacitors:
C1,C2 = 22pF
C3,C5 = 100nF
C4 = 10µF 16V radial

Semiconductors:
D1-D9,D11,D12 = LED, 3mm, red, high efficiency (low current)
D10 = LED, 3mm, green, high efficiency (low current)
T1-T9 = BC817
IC1 = 4051 SMD
IC2 = PIC16C57, programmed, order code **010204-41**

Miscellaneous:
JP1 = 2-way pinheader with jumper
K2,K4-K7,K9,K11 = servo connection cable
K1,K3,K8,K10 = 3-way pinheader
K12,K13,K14 = 5-way pinheader
X1 = 16MHz quartz crystal
PCB, order code **010204-1**
Disk, project source code files, order code **010204-11**

in which a single servo operates the coupling to the tractor and the associated support legs on the trailer. This double function is specially designed to be used with a Tamiya lorry trailer kit. If only the trailer coupling is needed, this function can naturally also be used with other model lorries.

Circuit operation

The heart of the controller is a Microchip PIC16C57 clocked at 16 MHz. The version in the DIL28 package is used, since this makes it easier to carry out possible software updates or extensions. The circuit, which is shown in schematic form in Figure 1, assumes the use of a battery eliminator circuit (BEC) providing a regulated supply voltage of 5 V.

The microcontroller evaluates the signals from seven output channels of the remote-control receiver. At each of these outputs, the receiver provides the well-known pulse-width modulated signal whose pulse width ranges from 1 to 2 ms (1.5 ms ± 0.5 ms). These signals, which control the gearbox, dipped/high beam, switched channel, hazard flasher, steering and motor ('gas') functions, are connected to pin headers K2, K4, K5, K6, K7, K9 and K11, respectively. From there, they reach inputs X0–X6 of the multiplexer (IC1), and from the multiplexer they arrive at port pins RA0–RA3 of the PIC microcontroller (IC2). The 4051 CMOS multiplexer could in principle be omitted, but then a larger and more expensive PIC would be needed.

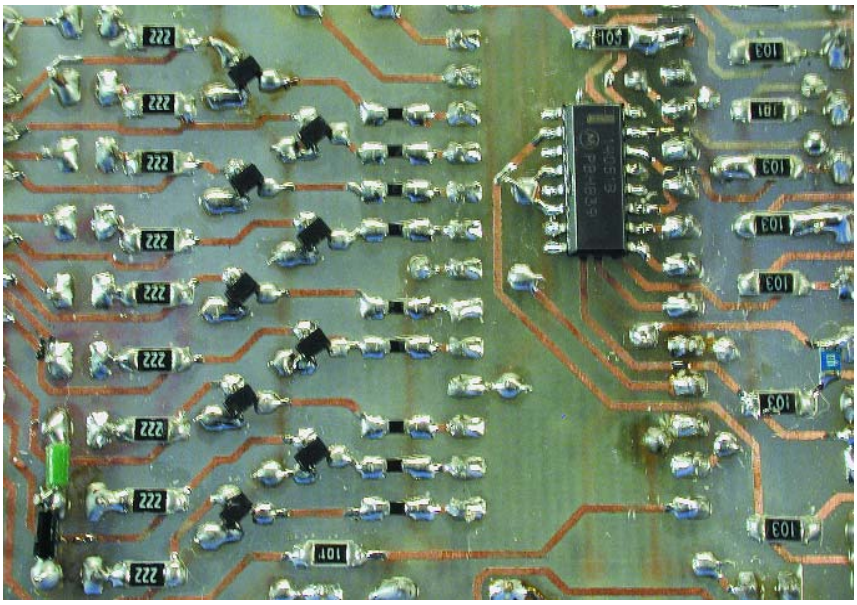


Figure 4. The SMD components are fitted on the bottom side of the circuit board.

The signals for the functions that are directly controlled by the remote controller (motor and steering) are not only passed on to the microcontroller, but are also looped directly through to output pin headers for connection to the steering servo (K8) and the motor speed controller (K10).

Port pin RB0 of the microcontroller is connected to jumper JP1. This jumper selects the direction of rotation of the servo for the trailer coupling. The amount of travel of the gear servo can be set using trimpot P1, which is connected to port pin RB1.

By programmed processing of the various input signals, the microcontroller generates control signals for two servo outputs (K1: gearbox servo and K3: trailer coupling servo) and eleven switched outputs that are available on pin headers K12, K13 and K14. Nine switched outputs are implemented as open-collector outputs using external transistors (T1–T9), while two output pins (of K14) are directly connected to port pins RC3 and RC4. **Table 1** presents a summary of the connectors with their designations and functions. If you are interested in the software that processes the signals in the PIC microcontroller, you can download it from the Free Downloads page on the *Elektor Electronics* website.

Each of the switched outputs is provided with a LED that indicates the output state (D1–D9 and D11). LED D10 has a special function. After the supply voltage is switched on, some of the signals from the microcontroller are first calibrated (such as the signals for the turn indicators, brake lights and back-up lights). The control stick must not be moved while this is happening. LED D10 is illuminated only after the initialisation has been successfully completed (which can take up to four seconds) in order to indicate that the circuit is ready to be used. LED D12 is connected to a switched channel that is not currently used (K14/3) and thus does not presently have any function. However, the author intends to use this output to support an infrared link between the tractor and the trailer.

Construction and use

Fitting the components to the printed circuit board (Figure 2) requires some special atten-

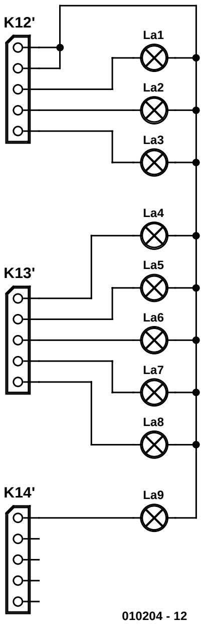


Figure 5. Lamp connections when using the internal supply voltage.

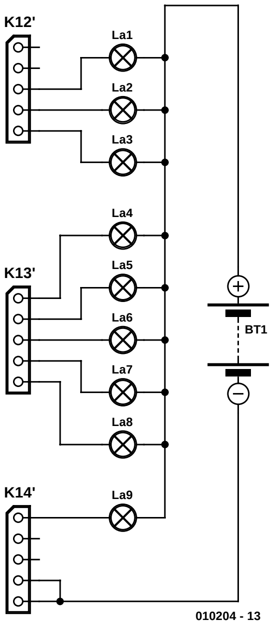


Figure 6. Lamp connections when using an external voltage source (5–12 V).

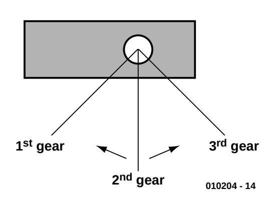
tion. Although the circuit board is single-sided, components are mounted on both sides. IC1 (a 4051 in an SMD package) is soldered to the copper side. Particular care is necessary in fitting transistors T1–T9, which are also mounted on the copper side. For fitting the components on the component side, it is best to start with the wire bridges. Attentive readers will probably notice that

Table 1. Summary of connections and functions

Gearbox: K1 & K2

K1: Gearbox servo connection (only for a 3-speed gearbox)
K2: Connection for the cable from the receiver 'gearbox' output.
Function on the remote control unit: rocker switch with three positions: up / off / down

Function:
The amount of servo travel to the left or right of the middle position can be set using P1. Any change in the setting of P1 becomes effective only after the power is next switched on. When the power is switched on, the servo always moves to the middle position (second gear).



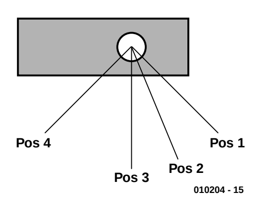
- rocker switch 'up' once → servo moves forward one position (e.g. from second gear to third gear).
- rocker switch 'down' once → servo moves backward one position (e.g. from second gear to first gear).

Trailer coupling: K3 & K4

K3: Connection for the trailer coupling servo (for a Tamiya lorry with electrically operated support legs – see text)
K4: Connection for the cable from the receiver 'trailer coupling' output.
Function on the remote control unit: rocker switch with three positions: up / off / down

Function:

- rocker switch 'up' → servo moves to position 1 (in this position, the support legs are lowered until a limit switch on the trailer is tripped).
- rocker switch 'off' → servo moves to position 3 (if the back-up light is not on, the coupling cannot be opened!).
- rocker switch moved to 'down' AND back-up lights ON → servo moves to position 2 (in this position, the support legs are lowered until a limit switch on the trailer is tripped).
  After the rocker switch has been released (it returns automatically to the middle position), the servo moves to position 4. The trailer coupling is now open and the tractor can separate from the trailer. The trailer coupling remains open until the switch is again moved to the 'up' position (to raise the support legs and close the trailer coupling).



Dipped beam / main beam: K5

K5: Connection for the cable from the receiver 'dipped beam / main beam' output.
Function on the remote control unit: toggle switch with three positions: up / off / down

Function:

- toggle switch set to 'up' → all lights out (K12/3&4)
- toggle switch 'off' → dipped beam on (K12/3)
- toggle switch 'down' → dipped beam and main beam on (K12/3&4)

Switched / keyed channel: K6

K6: Connection for the cable from the receiver '**switched/keyed channel**' output.
Function on the remote control unit: rocker switch with three positions: up / off / down

the arrangement of the components on the circuit board does not completely match the arrangement shown on the prototype board in the photos (**Figures 3 and 4**). This is because the final circuit board layout was modified slightly from that of the prototype, but the two circuit boards are electrically identical.

All essential information regarding connector pin assignments, wiring and use of the circuit board is presented in **Table 1**, with one exception: the connections for the lamps are shown in **Figures 5 and 6**. Outputs RB5–RB7 and RC0–RC7 of the PIC directly control the connected lights via the BC817 transistors. Since these outputs are implemented as open-collector outputs, the lamps can be connected either directly to the circuit board (as in Figure 5) or via an external supply voltage (using a separate battery as shown in **Figure 6**). In the latter case, one lead of each lamp is connected to the positive lead of the external supply voltage, which may lie in the range of 5–12 V. When connecting the lamps, take particular care to avoid any possibility of a short circuit between the +5-V supply voltage on pins 1 and 2 of K12 and the external supply voltage. Such a short circuit could destroy both the PIC and the remote control receiver!

Note that if the lamps are connected directly to the circuit board (as shown in Figure 5), the entire current for the lamps must be provided by the speed controller. Special lorry regulators can provide more current at the BEC output (5 V) than normal regulators for cars. In any case, the ratings of the lamps must be chosen such that the BEC supply is not overloaded (see the 'Lamp Current' sidebar). Relays can also be connected to the open-collector outputs, but only if they are fitted with flyback diodes. The maximum relay coil current is subject to the same considerations as the maximum lamp current.

(010204-1)

Function:
- rocker switch 'up' once → keyed channel on (K14/1)
- rocker switch again 'up' → keyed channel off (K14/1)
- rocker switch 'down' → switched channel on (K14/2)
- rocker switch 'off' → switched channel off (K14/2)

Important note:
The switched channel is only suitable for control purposes (max. 10 mA) – do not connect any lamps or relays without using suitable driver stages!

Hazard flasher: K7

K7: Connection for the cable from the receiver 'signal / hazard flasher' output. Function on the remote control unit: rocker switch with three positions: up / off / down

Function:
- rocker switch 'up' once → hazard flasher on (blinker R/L, K13/4&5)
- rocker switch again 'up' → hazard flasher off
- rocker switch 'down' once → flashing signal lights on (K13/2/3)
- rocker switch again 'down' → flashing signal lights off

L/R turn indicators and steering servo: K8/K9

K8: connection for steering servo
K9: Connection for the cable from the receiver 'steering' output. Function on the remote control unit: steering control stick

Function:
After the supply voltage is applied, the neutral position of the control stick is stored. Do not move the control stick until LED D10 is illuminated!

- control stick to the left → left turn indicator on (k13/5)
- control stick in the middle → all turn indicators off
- control stick to the right → right turn indicator on (K13/4)

Brake/back-up lights and speed controller: K10/K11

K10: connection for speed controller
K11: Connection for the cable from the receiver 'speed controller' output. Function on the remote control unit: control stick forward / reverse

Function:
After the supply voltage is applied, the neutral position of the control stick is stored. Do not move the control stick until LED D10 is illuminated!

- control stick in the middle position → brake lights on (k12/5)
- control stick forward → brake and back-up lights off
- control stick reverse → back-up lights on (k13/1)
- control stick moved from the reverse position to the middle position → brake and back-up lights on.

Web addresses

www.robbe.de	full range of products
www.multiplex-rc.de	full range of products
www.schulze-elektronik.com/index_uk.htm	regulators, chargers
www.kontronik.com/gate_engl.htm	regulators, motors
www.hacker-motor.com/english/englisch.html	motors
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